# Control of Odorous Gas at Massachusetts Landfills

In Support of 310 CMR 19.000, Solid Waste Management Regulations
Policy #BWP-06-?

Massachusetts Department of Environmental Protection
Bureau of Waste Prevention
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***This document is intended to guide parties in complying with the Solid Waste Regulations at 310 CMR 19.000 and the Air Quality Regulations at 310 CMR 7.00.***

**This Policy does not create any substantive or procedural rights, and is not enforceable by any party in any administrative proceeding with the Commonwealth. This Policy provides recommendations and guidance on approaches MassDEP considers acceptable for meeting the performance standards set forth in the Solid Waste Management Facility Regulations, 310 CMR 19.000, and the Air Quality Regulations, 310 CMR 7.00, and discussed in this document. Other options for demonstrating compliance with the regulations may be acceptable. The regulatory citations in this document should not be relied upon as a complete list of the applicable regulatory requirements.**

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## I. Introduction

A large number of odor complaints have been made over the past several years by people living or working near landfills, and in particular landfills that have been using construction and demolition (C&D) residuals and fines as daily cover and/or grading and shaping material. However, any landfill can experience odor problems. The Massachusetts Department of Environmental Protection (MassDEP) is concerned about emissions of hydrogen sulfide ($H_2S$) as well as other landfill gasses and is focusing on prevention, identification, quantification and control of $H_2S$ emissions as a means of addressing both. By virtue of the occurrence of $H_2S$ along with other landfill gasses, MassDEP anticipates that efforts to control $H_2S$ emissions will have the added benefit of controlling emissions of other landfill gasses as well. This document provides guidance on recommended management practices to prevent or minimize generation of odors for landfills, and in particular, those proposing to use C&D residuals and/or fines as daily cover and/or grading and shaping material. In addition, this document provides guidance on conducting assessments and response actions to abate odorous landfill gas emissions caused by hydrogen sulfide or other malodorous landfill gas emissions. This document is not intended to address landfill soil gas migration and safety (i.e. explosion) concerns associated with methane and related corrective actions.

Hydrogen sulfide and other landfill gas emissions can be prevented or minimized by instituting proper operation and maintenance at a landfill. But, where odor problems occur, the decision about whether hydrogen sulfide and other malodorous landfill gas emissions require corrective actions depends on a number of factors such as the presence of ongoing emissions, adjacent land

uses, the presence of an exposed population, the location of the facility, and the concentration of landfill gases.

Where a problem does occur, MassDEP has established two tracks for taking actions at facilities. The first is triggered by the presence of odors at or in the vicinity of a facility. The second is triggered by the presence of hydrogen sulfide at a concentration exceeding the action level at a facility compliance point, usually at or near the property line, regardless of whether odors have impacted anyone near the facility. These two tracks are the primary tools for making decisions on when landfill gas emissions are at concentrations that would require additional assessment and corrective actions. This document is intended to assist regulators and the regulated community in making decisions that are both consistent from landfill to landfill and protective of public health, safety and the environment. Additionally, this document includes Recommended Management Practices ("RMPs") for landfill operations that will reduce the potential for generation of landfill gas odors and the production of hydrogen sulfide gas.

The regulatory citations provided throughout this document are not meant to be a complete list of all the regulatory requirements concerning landfill gas emissions, air quality requirements and risk characterization at Massachusetts's landfills. In addition, there is uncertainty with regard to whether the RMPs will reduce or eliminate landfill gas odors and $H_2S$ emissions to acceptable levels due to site-specific considerations. Therefore, the list of actions to be taken by landfill operators in Table 1 and the RMPs suggested by MassDEP should be considered minimum management practices to be instituted should there be a problem at a landfill. If these measures are not successful in reducing $H_2S$ emissions and eliminating odor problems MassDEP may require other measures to be taken until the $H_2S$ emissions and/or odor problems are resolved in accordance with 310 CMR 19.117, 19.130, 7.01 and 7.09.

## II. Regulatory Background

The general landfill design standards and operational standards related to air quality are established within the Solid Waste Management Regulations at 310 CMR 19.117 (Air Quality Protection Systems) and 310 CMR 19.130 (Operation and Maintenance Requirements). MassDEP's regulations at 310 CMR 19.117 state, in part, that owners, operators and permittees of solid waste facilities have a duty to:

> *control the concentration levels of explosive and malodorous gases and other air pollutants as necessary in order to maintain air quality and to prevent the occurrence of nuisance conditions or public health or safety problems.*

MassDEP's regulations at 310 CMR 19.130(16) Vector, Dust and Odor Control, state in part, that:

> *The operator shall prevent vectors, dust, odors and other nuisance conditions from developing at the landfill and any other areas related to the general facility operations.*

The general air quality standards related to landfills are set forth in 310 CMR 7.00. MassDEP's Air Quality regulations at 310 CMR 7.00 define Air Pollution as:

> *the presence in the ambient air space of one or more air contaminants or combination thereof in such concentrations and of such duration as to:*

*a) cause a nuisance;*
*b) be injurious, or be on the basis of current information, potentially injurious to human or animal life, to vegetation or to property; or*
*c) unreasonably interfere with the comfortable enjoyment of life and property or the conduct of business.*

The Air Quality regulations at 310 CMR 7.01(1) state:

*No person owning, leasing, or controlling the operation of any air contamination source shall willfully, negligently, or through failure to provide necessary equipment or to take necessary precautions, permit any emission from said air contamination source or sources of such quantities of air contaminants which will cause, by themselves or in conjunction with other air contaminants, a condition of air pollution.*

The Air Quality regulations at 310 CMR 7.02(1)(b) state, in part, that:

*A plan approval is required prior to any construction, substantial reconstruction, alteration, or subsequent operation of a facility that may emit contaminants to the ambient air.*

The Air Quality regulations at 310 CMR 7.09(1) state, in part, that:

*No person having control of any dust or odor generating operations such as, but not limited to…dump operations…shall permit emissions therefrom which cause or contribute to a condition of air pollution.*

This document provides guidance for meeting the general requirements set forth in the Solid Waste Management Regulations at Massachusetts landfills to protect public health, safety and the environment. Persons using this Policy should be aware that there may be other acceptable alternatives to specific actions required by this guidance for achieving compliance with the regulations.

## III. Permitting Considerations

The most important consideration in preventing the generation of odors is to properly design and operate a landfill to minimize the potential for generation of odors and $H_2S$. Landfill gas collection and control systems need to be properly designed and operated so that $H_2S$ and other odorous gasses are adequately controlled and secondary problems are not created, such as overloading a landfill flare with $H_2S$, which causes emissions of $SO_2$ from the flare to exceed permitted levels.

This document provides a number of Recommended Management Practices (RMPs) in Table 2 that landfill owners/operators should include in the operation of their facility, particularly in applications where C&D residuals and fines are to be used for daily cover or as grading and shaping material in the closure of a landfill. Where landfills will use C&D residuals and/or fines MassDEP will require applicants to provide:

- adequate designs for gas collection and treatment systems, including pre-treatment systems to reduce $H_2S$
- adequate monitoring and maintenance of gas collection and treatment systems;

- a financial assurance mechanism (refer to 310 CMR 19.051: Financial Assurance Requirements) that includes monitoring and maintenance of gas collection and treatment systems through closure and post-closure and to address contingencies for remedial activities.

## IV. Action Levels for Odorous Landfill Gas Emissions and Hydrogen Sulfide

This Policy establishes both an odor Action Level and a hydrogen sulfide Action Level as the primary tools for making decisions about when landfill gas emissions are serious enough to require assessment, monitoring and/or corrective actions. Please note, a landfill may be required to take action to address a condition of air pollution pursuant to 310 CMR 7.01 or 7.09(1) even where action levels are not exceeded.

This Policy establishes two Action Levels for implementing measures to address the release of odorous gases from landfills. The Odor Action Level is not based on a specific hydrogen sulfide concentration, but on the detection of odors from emissions of any landfill gasses and the presence of odors at nuisance levels offsite (indicated by odor complaints from the public and/or local Board of Health, landfill personnel or MassDEP observation). The $H_2S$ Action Level is based on measured hydrogen sulfide levels in ambient air at the point of compliance established in a permit, plan or approval or the property boundary over specific time periods. Table 1 lists the two Action Levels along with information on what constitutes an exceedance of an Action Level and subsequent response actions.

An exceedance of the Action Levels triggers immediate investigation, monitoring and corrective actions by landfill owners/operators to abate the odorous gas emissions. Each owner/operator at an affected landfill will be required to have a site-specific Hydrogen Sulfide and Odorous Landfill Gas Response Plan (see Section V.) that is to be followed when assessing and implementing response actions. This additional assessment and/or monitoring is necessary to determine the extent and severity of the emissions of hydrogen sulfide/landfill gas and ensure that the public is not exposed to hydrogen sulfide concentrations that may cause a nuisance condition or pose a potential risk to public health and/or safety.

The Action Levels listed in Table 1 are based on a review of monitoring data from Massachusetts landfills, review of exposure limits for hydrogen sulfide from various sources, and experience gained by MassDEP staff at landfills with odors and/or hydrogen sulfide emissions. The $H_2S$ Action Level is a two-part level based upon either exceeding 15 ppb over an 8-hour period or 30 ppb over a 1-hour period. These levels were selected in order to capture both longer term, low level releases of $H_2S$, as well as shorter term spikes of $H_2S$. These thresholds were selected as a trigger for taking further actions at the landfill to abate potential odor problems before they begin, where there has not already been an exceedance of the odor threshold, and to require the landfill operator to take actions before a condition arises that could impact public health.

Hydrogen sulfide is one of the most common compounds responsible for landfill odors and can have an extremely low odor threshold (the lowest reported value is 0.5 ppb in Ruth, 1986 cited in

ATSDR, 2004[1]), but levels at which odors become apparent may vary significantly. While hydrogen sulfide can be odorous and irritating at very low concentrations for some people and can create a nuisance off-site, MassDEP established a hydrogen sulfide Action Level in addition to the Odor Action Level to cover situations where odors are not detected. The hydrogen sulfide Action Level is set at a greater concentration than the lowest reported odor threshold for hydrogen sulfide. Therefore, at most landfills with hydrogen sulfide emissions, landfill operators may need to begin assessing and mitigating hydrogen sulfide concentrations as a result of odor complaints and not as a result of an exceedance of the $H_2S$ Action Level. The $H_2S$ Action Level will cover those situations where no one lives near the landfill or where people are not as sensitive to $H_2S$ odors.

[1] Ruth, JH. 1986. Odor thresholds and irritation levels of several chemical substances – A review. Am Ind Hyg Assoc J 47142-51. Cited in Agency for Toxics Substances and Disease Registry. 2004. Draft Toxicological Profile for Hydrogen Sulfide. Atlanta, GA.

## Table 1: Minimum Response Actions for Odorous Gas Emissions[1]

| Action Level | Averaging Time | Frequency of Exceedances Triggering Action | Defined Exceedance | Sampler/ MDL Required | Action(s) To Be Taken by Landfill Operators<br>Landfill operators will be required to have a site-specific Hydrogen Sulfide & Odorous Landfill Gas Response Plan (Response Plan) that will be followed in investigating and addressing all odor complaints. The Plan will address the following activities: |
|---|---|---|---|---|---|
| Odor Action Level | Any | Any | Detection of odor (Investigate and verify) | Public complaints, Board of Health, landfill personnel[2], MassDEP personnel, ambient air sampling | 1. Log the complaint/detection of odors and contact local health officials and the Department within 24 hours.<br>2. Investigate the complaint to determine the source and extent of the odors to determine the severity of the odor problem (see Appendices).<br>3. Implement corrective actions, if necessary, including, but not limited to:<br>a. cease acceptance of any material that has the potential to contribute to odorous landfill gas emissions, on at least a temporary basis; and<br>b. place additional daily or intermediate cover soils or apply other cover technologies to reduce odorous landfill gas emissions to ambient air.<br>4. Conduct landfill gas monitoring if verified odors have not been traced to a particular source and remedied.<br>5. Conduct other activities as necessary and/or as directed by MassDEP to control nuisance odors (see 6, 7, and 8 below). |
| $H_2S$ Action Level (The action level is based upon either exceeding 15 ppb averaged over an 8 hour period or 30 ppb averaged over a 1 hour period) | 8-hour | 1 | 15 ppb or greater averaged over any 8-hour period[3] | Continuous monitoring devices (e.g. Jerome Meter) sampling every ten minutes at a detection limit of 3 ppb | 1. Log the detection of any exceedances and contact local health officials and the Department within 4 hours for exceedances of the $H_2S$ Action Level.<br>2. Investigate and determine the source and extent of the exceedance following the protocols in the appendices.<br>3. Immediately:<br>a. cease acceptance of any material that has the potential to contribute to hydrogen sulfide emissions, on at least a temporary basis; and<br>b. place additional daily and intermediate cover soils or apply other cover technologies to reduce hydrogen sulfide emissions to ambient air.<br>4. Conduct additional ambient air monitoring off-site or evaluate need for additional off-site monitoring.<br>5. Implement 24-hour continuous air monitoring for hydrogen sulfide in ambient air, and daily near surface monitoring on the landfill.<br>6. In addition, the following actions may be required if directed by MassDEP:<br>a. install an active landfill gas control system with landfill gas treatment (combustion and/or non-combustion technologies);<br>b. evaluate the need for the installation of a final cover system with an active landfill gas control system on an expedited schedule.<br>7. Implement a Community Communications Plan, providing notification to the community and local medical/emergency response personnel that hydrogen sulfide concentrations, if they were to migrate off-site, may create an odor nuisance condition. Conduct additional ambient air monitoring off-site to determine the hydrogen sulfide concentration at receptor locations. |
| | 1 hour | 1 | 30 ppb or greater averaged over any 1 hour period[3] | | |

[1] In response to an odor problem or $H_2S$ problem at a landfill, MassDEP may require any and all actions necessary to resolve odor and $H_2S$ problems and to protect public health, safety and the environment.

[2] Landfill personnel should investigate complaints by following *"Recommended Protocol for the Assessment of Offsite Landfill Odors" (refer to Appendix E)*

[3] Result based on a rolling average

## V. Hydrogen Sulfide and Odorous Landfill Gas Response Plan

### A. General

Due to the potential threat of nuisance odors and potential risk to public health associated with hydrogen sulfide emissions, MassDEP will require investigations and response actions on an expedited schedule in response to an exceedance of an Action Level. The expedited schedule will be made possible, in part, by the advance preparation of a Hydrogen Sulfide and Odorous Landfill Gas Response Plan (the "Plan") (see Appendix C) by the landfill owner/operator prior to: operation of a new landfill; any new expansion of an existing landfill; closure of an unlined landfill that will accept any C&D fines and residuals for grading and shaping material to achieve closure grades; or as otherwise required by MassDEP. Also, MassDEP may require a facility to develop a Plan as part of corrective actions at an existing landfill experiencing odor problems. The development of this Plan is crucial to enable a quick assessment and abatement of hydrogen sulfide and other landfill gas emissions.[4] The Plan must include, at a minimum, information regarding receptors, communication, monitoring and response actions to be taken in response to odor nuisances or hydrogen sulfide in ambient air at concentrations equal to or greater than the $H_2S$ Action Level.

Some landfills in Massachusetts already have established procedures for responding to complaints, including odor complaints. These procedures are designed to allow the facility owners/operators to quickly investigate the potential cause of the odor leading to a complaint and immediately implement corrective actions. A Plan will formalize and build upon those procedures already in place at these landfills. Each landfill owner/operator that is required to submit a Plan shall submit their site-specific Plan as part of the Authorization to Operate application, Major or Minor Permit Modification application, or Corrective Action Design application, dependent upon the site-specific circumstances. Additional guidance regarding the preparation of the Plan is provided in Appendix C.

The Plan should include an Odor Survey Plan that identifies locations in the vicinity of the landfill that personnel assigned to investigate an odor complaint shall visit and determine if odors are present. These locations shall be selected based upon, but not limited to, the following criteria: the proximity to the landfill, receptors, topography, meteorology, predominant wind direction, and other potential sources of odors and emissions. The landfill owner/operator will develop procedures and protocols for logging a complaint, investigating a complaint, conducting landfill gas emissions monitoring and implementing corrective actions. These procedures should be incorporated in the Hydrogen Sulfide and Odorous Landfill Gas Response Plan for the site. Refer to Appendix C, Appendix E and Table 1 for additional guidance for the preparation of Hydrogen Sulfide and Odorous Landfill Gas Response Plan.

[4] Additional information regarding when landfill owner/operators will have to prepare a Plan is included in Appendix H, Frequently Asked Questions.

## B. Assessment, Monitoring and Response Actions for Odor Action Level Events

Odor Action Level Event investigations and response actions are required upon the receipt of a complaint or detection of odors off-site at nuisance levels. In addition to off-site odors, landfill personnel should be cognizant of odors that exist on-site that have the intensity and duration to potentially migrate off-site. Therefore, each landfill owner/operator should take all necessary actions as soon as possible when an odor is detected on site, even before a complaint is placed.

In general, MassDEP expects the following assessment, monitoring and response actions to be implemented in response to an Odor Action Level Event.

1. The landfill owner/operator will immediately log the complaint/detection of odors and contact local health officials and MassDEP within 24 hours.
2. The landfill owner/operator will investigate the complaint to determine the source and extent of the odors following their Response Plan.
3. The landfill owner/operator will implement the recommended management practices, if necessary, including, but not limited to:
    a. cease acceptance of any material that has the potential to contribute to odorous landfill gas emissions, on at least a temporary basis; and
    b. place additional daily or intermediate cover soils or apply other cover technologies to reduce odorous landfill gas emissions to ambient air.
4. The landfill owner/operator will conduct landfill gas monitoring if verified odors have not been traced to a particular source and remedied.
5. The owner/operator shall conduct additional investigations including, but not limited to, landfill gas characterization, emission monitoring, near-surface landfill gas monitoring and ambient air monitoring (refer to Appendix B, Landfill Gas Monitoring). This monitoring shall be performed to determine the nature, source and extent of the emissions ongoing at the landfill site.

The owner/operator shall implement progressively more comprehensive corrective actions as necessary to resolve nuisance odor conditions at the site. Please refer to the $H_2S$ Action Level for possible additional response actions. Also, persistent nuisance odor conditions that result in non-compliance with the regulations may result in MassDEP taking enforcement.

## C. Assessment, Monitoring and Response Actions for $H_2S$ Action Level Events

The $H_2S$ Action Level for hydrogen sulfide is listed in Table 1, along with information on recommended sampling equipment, averaging times, what constitutes an exceedance of the Action Level and associated response actions. In order to determine if a hydrogen sulfide Action Level has been exceeded, air monitoring equipment must be employed. MassDEP recommends that continuous monitoring devices be used with the detection limits in the range of single parts per billion. Most continuous monitoring devices can be adjusted to collect readings on a set time interval (every few minutes-hours). MassDEP recommends that the meter initially be set to collect hydrogen sulfide readings every 10-15 minutes. Appendix B –Landfill Gas Monitoring - includes basic information about the design and implementation of ambient air monitoring at landfills. However, this document does not focus on how to conduct air monitoring and

MassDEP recommends that professionals experienced with ambient air monitoring procedures and protocols be consulted.

The landfill owner/operator will implement assessment, monitoring and response actions in accordance with this policy and an approved site-specific Response Plan when hydrogen sulfide concentrations in ambient air are greater than or equal to the $H_2S$ Action Level to comply with 310 CMR 19.117, 19.130, 7.01 and 7.09.

## D. General Conditions for the $H_2S$ Action Level

1. In order to have an exceedance of the $H_2S$ Action Level, the following two criteria must be satisfied:
    a. Hydrogen sulfide must be detected in ambient air at or beyond the point of compliance (POC) established in a permit, plan or approval or the property boundary; and
    b. The average concentration of hydrogen sulfide measured in ambient air at this location must be greater than or equal to 15 ppm averaged over 8 hours or 30 ppb averaged over one hour once over a 24-hour period.

2. MassDEP expects the following initial response, assessment and monitoring activities will be implemented by the landfill owner/operator when hydrogen sulfide concentrations in ambient air are greater than the $H_2S$ Action Level:
    a. Immediately log the detection of any exceedances and contact local health officials and the Department within 4hours for exceedances of the $H_2S$ Action Level.
    b. Investigate and determine the source of the exceedance following the protocols in the Response Plan.
    c. Immediately:
        i. cease acceptance of any material that has the potential to contribute to hydrogen sulfide emissions, on at least a temporary basis.
        ii. place additional daily and intermediate cover soils or apply other cover technologies to reduce hydrogen sulfide emissions to ambient air.
    d. Implement 24-hour continuous air monitoring for hydrogen sulfide in ambient air and daily near surface monitoring on the landfill.
    e. Conduct additional ambient air monitoring off-site or evaluate need for additional off-site monitoring.

3. The following Corrective Actions will be implemented by the landfill owner/operator when hydrogen sulfide concentrations in ambient air are greater than the $H_2S$ Action Level as directed by MassDEP on a case-by-case basis depending on site-specific factors:
    a. Install a passive landfill gas control system (passive vents) that can be retrofitted to become an active gas collection and control system (combustion and/or non combustion technologies).

b. Evaluate the need for the installation of a final cover system with an active landfill gas collection and control system on an expedited schedule.
c. Implement a Community Communication plan, providing notification to the Community and local medical/emergency response personnel that hydrogen sulfide concentrations, if they were to migrate off-site, may create an odor nuisance condition.

4. In addition to the activities required above, the landfill owner/operator will implement the additional Assessment and Monitoring and Corrective Actions specified below when directed by MassDEP.
    a. Install a cap with an active landfill gas collection and control system.

## VI. Recommended Management Practices

MassDEP requires that landfill operators incorporate procedures and practices that will prevent potential impacts to air quality and nuisance conditions from developing at the facility. MassDEP refers to these procedures and practices as Recommended Management Practices ("RMPs"). In the context of this Policy, a RMP is a preventive technology or measure that is implemented to limit potential impact to air quality by a landfill and to address nuisance and public health concerns. The RMPs discussed in this guidance are designed to prevent and/or reduce the potential impact from hydrogen sulfide and odorous landfill gas emissions. These RMPs may evolve over time and the landfill owner/operator may be required to take further actions beyond the RMPs to resolve persistent odor problems or $H_2S$ problems at a landfill. The RMPs discussed below are summarized in Table 2.

### A. Active Face and Cover Materials

1. **Active Face**

The operator should carefully evaluate the size of the active face, generally trying to keep it as small as possible as this will limit the surface area of exposed waste, both reducing the potential for odor as well as limiting the area needing cover soils.

2. **Cover Materials**

The type and quantity of cover materials should be selected with odor control in mind. Soil daily cover materials may need to be placed more frequently than once a day and the effective quantity to control odor may be more than the minimum 6 inches required by regulation.

Some synthetic spray-on cover materials may both create a more gas tight surface as well as have components that can act as odor neutralizing agents, such as lime-based products.

Intermediate cover may prove to be an effective odor control method and its use should be considered on a more frequent basis than the minimum regulatory requirement of placing intermediate cover when waste will be left exposed for more than 30 days.

| Table 2. Recommended Management Practices | |
|---|---|
| **BMP** | **Suggested Practice** |
| Active Face | • Evaluate size of active face<br>• Keep as small as possible to limit surface area exposed and need for cover material<br>• Provide good compaction and proper grading to reduce infiltration of storm water into waste |
| Cover Materials | • Select the type and quantity of cover material to control odors<br>• Evaluate the need to place cover material more than once per day<br>• Evaluate the need to apply greater than 6 inches of cover material<br>• Provide good compaction of cover material to reduce chances of odor "breakouts"<br>• Consider use of synthetic spray-on materials to help control odors more effectively<br>• Consider use of lime-based products, which can neutralize odors<br>• Evaluate the frequent use of intermediate cover, which can be effective for controlling odors |
| Sequencing Plan | • Plan carefully for the location, sizing and timing of placement of waste and cover materials<br>• Bring active areas to grade quickly, then place final cover and gas controls on newly completed areas |
| Gas Collection and Control Systems | • Develop a contingency plan for installing an active gas collection and control system, including, where necessary, hydrogen sulfide pre-treatment systems that are appropriately sized to pre-treat the volume of gas generated<br>• Install gas control system during active landfilling where possible:<br>o Include sacrificial, horizontal, perforated gas collection pipes<br>o Gas extraction wells can be installed prior to placement of final cover<br>• Passive system should be designed to be retrofitted and operated as an active system within short period of time<br>• Include sufficient funding in the facility's Financial Assurance Mechanism to ensure proper operation and maintenance of the gas collection and control systems during the life of the facility and the post-closure period |
| Gas Collection and Control System Operations | • Provide proper training for all landfill operators<br>• Provide routine balancing of the active gas collection and control system well-field<br>• Provide routine monitoring and maintenance, including monitoring of and change-out of media in sulfur pre-treatment systems as needed<br>• Conduct routine inspections for settlement, leaks and condensate levels and water levels to ensure well screens are not blocked |
| Gypsum Removal | • If using C&D Fines or C&D Residuals at the landfill, only accept C&D materials from facilities that remove gypsum materials from the C&D<br>• Gypsum should be removed from the C&D material prior to any processing of the remaining C&D materials<br>• C&D processing facility should provide landfill with certification that gypsum has been removed |
| Mixing Ratios: Soil and C&D Debris Fines and Residuals | • Mix soils with fines or residuals to reduce the generation of hydrogen sulfide<br>o Consider the use of coal ash and wood ash to reduce odors<br>• Mix C&D residuals and fines with soils at a 1:1 ratio, or greater, of soils to residuals and fines by volume<br>• Cover all C&D fines or residuals at the end of the working day |

## B. Sequencing Plan

Attention to the landfill's sequencing plan – the location, sizing and timing of placing waste and cover materials – can help control landfill gas emissions by bringing active areas up to grade quickly and placing final cover and landfill gas controls on newly completed sections of the landfill.

## C. Gas Collection and Control Systems[5]

Consideration should be given to evaluating the use of a gas collection and control system that can be installed during active landfilling (sacrificial active gas systems, candle stick flares, etc.) instead of just implementing landfill gas controls as part of the final cover system. At a minimum, a contingency plan for installing a landfill gas collection and control system should be part of a landfill's approved operating permit. Please note that any passive gas system should be designed to be retrofitted and operated as an active gas collection and treatment system within a short period of time to address odors or $H_2S$ exceedances.

Sufficient resources to ensure the proper operation of a landfill gas collection and treatment system can also be a critical factor in the successful operation of a landfill gas and odor control system.

## D. Gypsum Removal

The landfill owner/operator should only accept construction and demolition (C&D) materials from C&D processing facilities that have implemented an aggressive program for the separation and removal of gypsum materials from the C&D. The gypsum removal should occur prior to processing. The C&D processing facility should furnish the landfill owners/operators with certification that gypsum has been removed prior to acceptance of this material either for disposal or grading and shaping.

## E. Mixing Ratios: Soil and Construction and Demolition Debris Fines and Residuals

MassDEP recommends that soil be mixed at a minimum rate of one part soil to one part construction and demolition debris ("C&D") fines and residuals, measured by volume. MassDEP has reviewed different methods to accomplish this mixing, taking into consideration operations at both active landfills and at closure operations at unlined landfills. The method that was most successful consisted of placing and spreading C&D fines and/or residuals within the active area, approximately one foot thick. Then soil, a minimum of one foot thick, is placed and spread over the C&D fines/residuals, followed by "tracking" with a bulldozer to thoroughly mix the soil into the C&D fines/residuals. Finally, the area is compacted and covered with other cover materials as may be necessary to control odors or other nuisance conditions. In addition,

[5] Landfills subject to NSPS Subpart WWW (have a design capacity greater than 2.5 million Mg (2.75 million tons)) and with NMOC emissions greater than 50 Mg/yr are required to have a gas collection and treatment system (refer to Appendix F).

other materials may be useful in reducing odors when mixed with fines and residuals, including coal ash and wood ash.

## VII. Appendices

The appendices listed below are intended to facilitate the development of the hydrogen sulfide and odor management plans and components.

Appendix A - Basics of Landfill Gas (Methane, Carbon Dioxide, Hydrogen Sulfide and Sulfides)
Appendix B - Landfill Gas Monitoring
Appendix C - Checklist for Hydrogen Sulfide and Odorous Landfill Gas Response Plans
Appendix D - Action Level – Data Collection and Action Level Exceedance Examples
Appendix E - Recommended Protocol for the Assessment of Off-Site Landfill Odors
Appendix F - Landfill Gas Control Technologies
Appendix G - Health, Safety & Welfare (Nuisance) Issues Associated with Hydrogen Sulfide and Odorous Landfill Gas
Appendix H - Frequently Asked Questions

Mention of trade names or commercial sources in this guidance document is for identification purposes only and does not imply endorsement or recommendation by MassDEP.